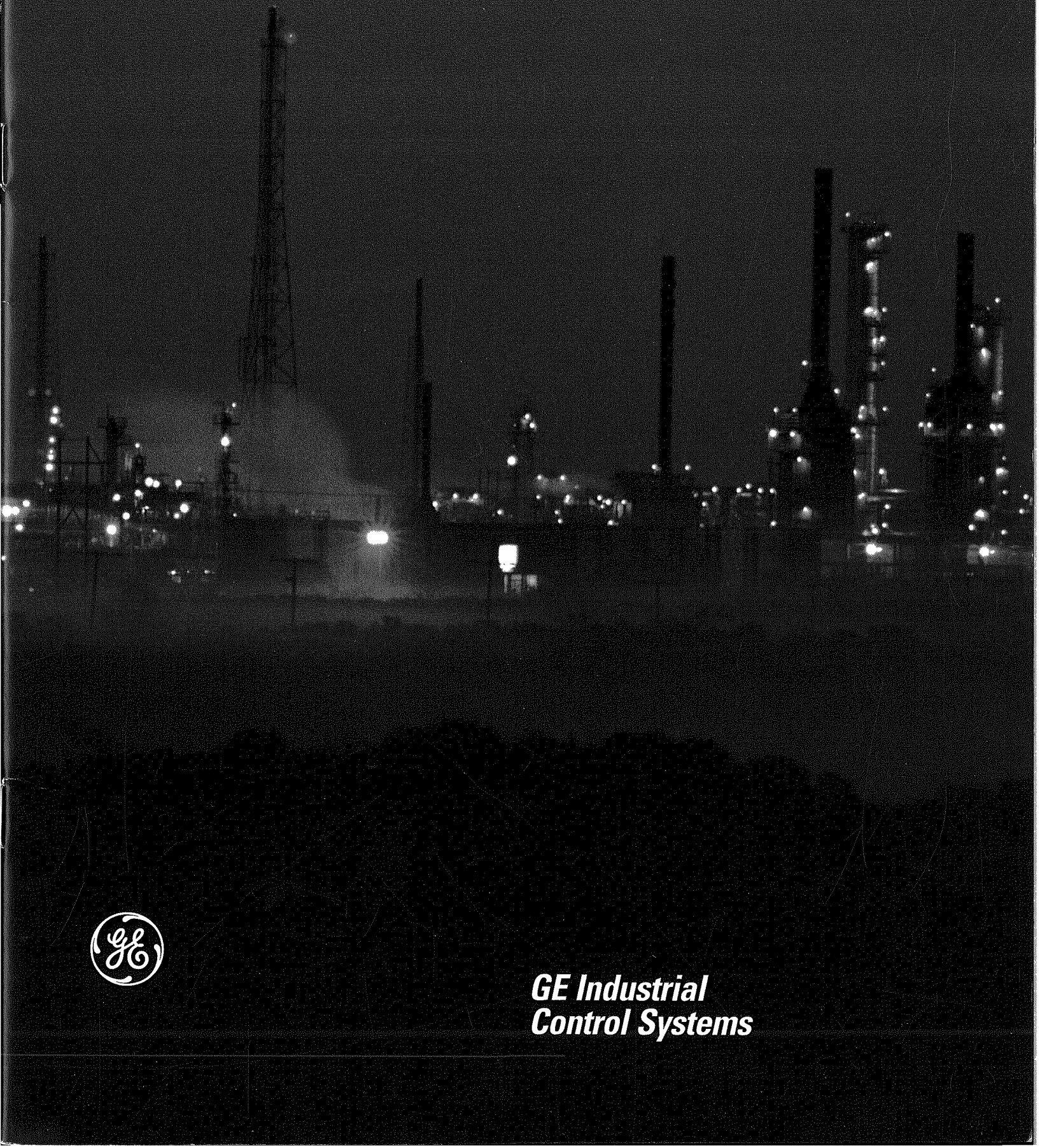
The INNOVATION™ Series LCI Load Commutated Inverter



GE Industrial Control Systems

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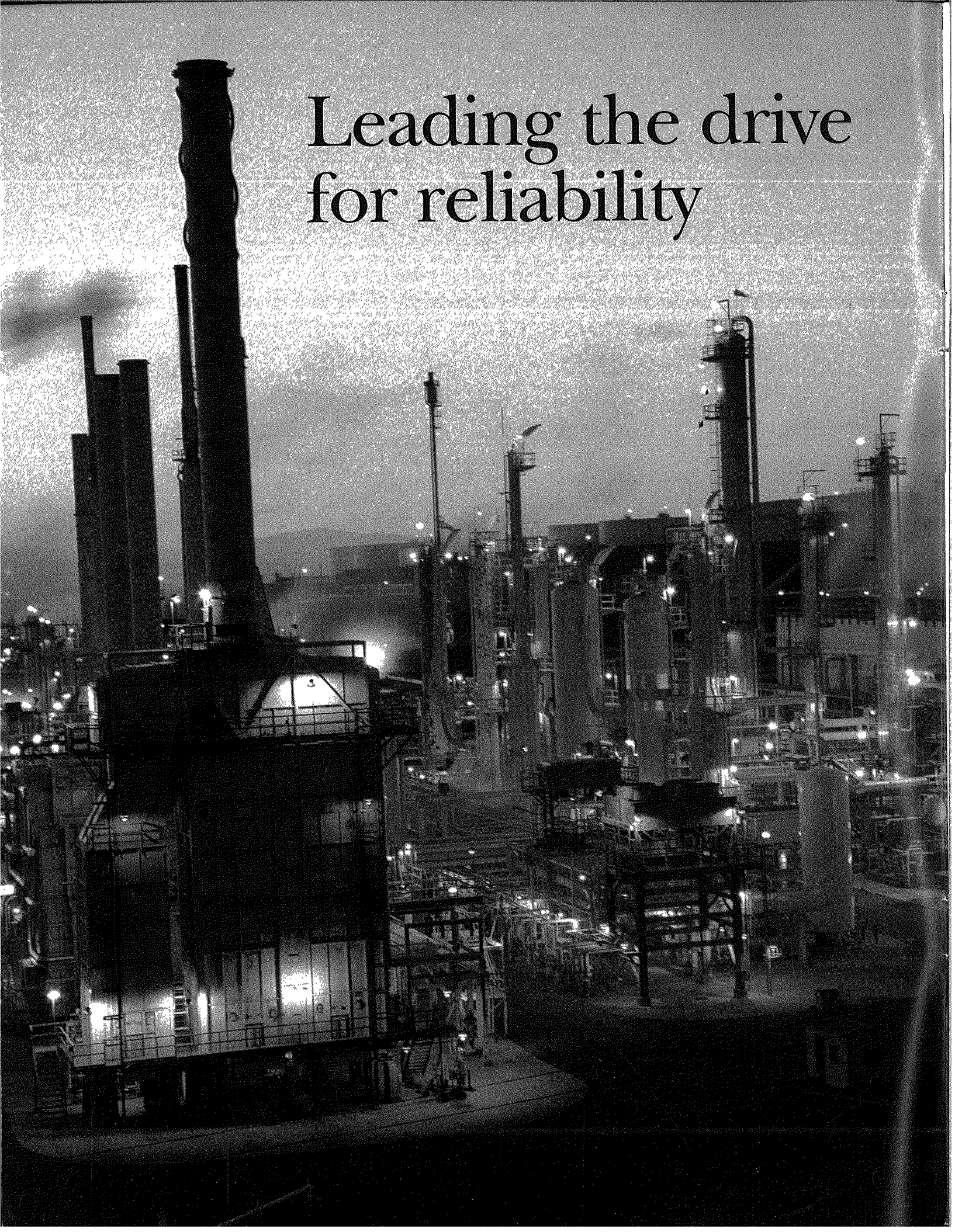
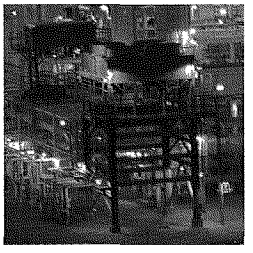


GE's highly successful LCI Load Commutated Inverter was one of the first commercially available large ac drives. It earned a well deserved reputation for being "motor friendly." Today many of these units have been in service for more than fifteen years driving fans, pumps, and compressors; and they can be found in ore grinding applications, rod and bar mills, and marine propulsion systems throughout the world. GE LCI products have enabled owners to realize their system's full potential with historical performance of 99.76% availability. The design objectives of the INNOVATION™ LCI product were focused on advancing product reliability and diagnostics intelligence to build on this impressive record and to offer our customer new levels of competitive performance.

During the past decade, ac drives have become an essential part of the industrial drive spectrum. Heavy industries, power suppliers, and motor manufacturers have come to recognize the energy savings and important benefits they can provide.



Now GE gives you more...

You can get higher drive reliability and control performance and better fault avoidance with the INNOVATION™ Series Load Commutated Inverter. This new LCI from GE features a floating point digital signal processor control that provides twenty times more processing power than the previous generation controls. The result — better performance and more comprehensive, higher quality protection and diagnostics.

Immunity to electrical noise is increased. Fiber optics are used to galvanically isolate control signals from high voltage circuitry for noise immunity and safety. Control circuitry has been simplified. The number of control circuit cards has been reduced, so there are fewer connections. Repairs have been simplified and there are fewer spare parts to stock.

It is the simplest, most efficient and most reliable ac adjustable speed drive technology available, and is the drive of choice for large, new synchronous motor applications which require speed control. The LCI is designed to be able to operate continuously at rated torque from near zero to rated speed. Its high starting and accelerating torque capability make it ideal for large conveyors, metal processing, rod, bar, and wire mills, as well as various extrusion, mixing, grinding and compressor applications.

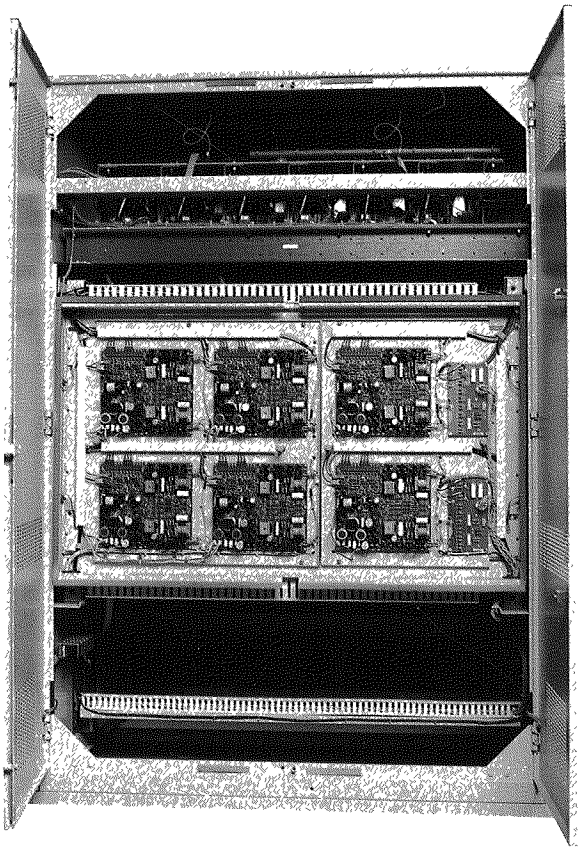
The advantages you need to keep ahead

High Efficiency

Today there are still many processes using a constant speed motor with mechanical flow control. This has been compared to a driver driving with the emergency brake engaged. The LCI enables process operators to adjust the speed of the motors, drawing only the power necessary to attain the required output. The result is a significant increase in efficiency, especially at low levels of flow or output.

Precise Process Control

The LCI controls both the motor current and power factor to control torque and speed. The digital accuracy of the equipment enables the system to provide the speed regulation required for many critical process operations.



Extended Motor Life

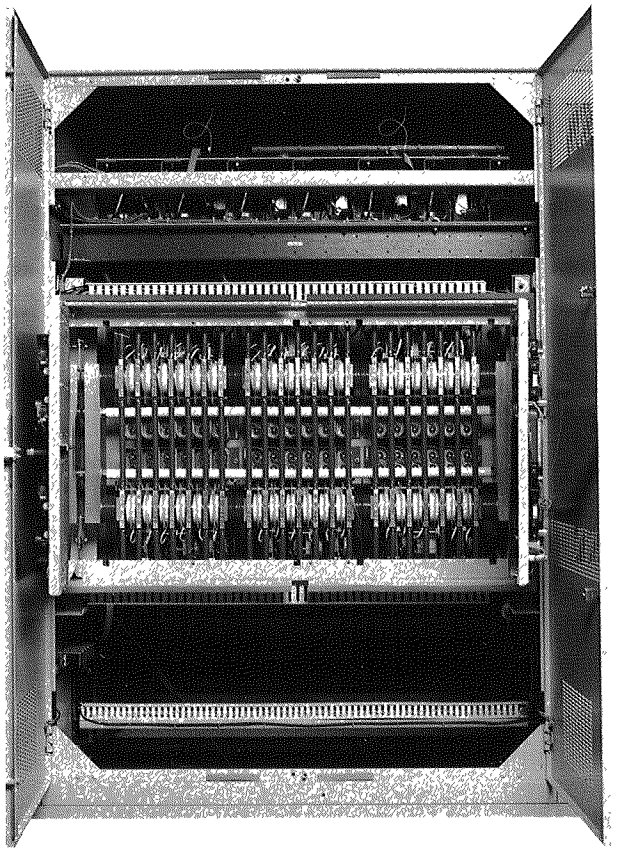
The motor current is always under control. No locked rotor starting currents, excessive temperatures, or mechanical stresses are put on the motor. With constant speed motors, the driven equipment is subjected to hard starts; and the heat, caused by the starting current, degrades the motor insulation and shortens its life. Controlled motor current also means that motor heating will not limit the quantity or frequency of motor starts.

Reduced Bus Impact

The LCI possesses characteristics that can increase the load carrying capability of an auxiliaries' system bus with a given switchgear rating.

The characteristics contributing to this are:

- Starting currents that are low in magnitude and of relatively high power factor when compared to across-the-line starting of conventional, squirrel-cage induction and synchronous motors. This characteristic eliminates significant voltage dips during the starting of large adjustable speed drives.



- Normally there is no LCI contribution to short circuit current. This characteristic permits a reduction in the auxilliary transformer's impedance. This results in improved system voltages at a given load condition or permits greater load carrying capability.

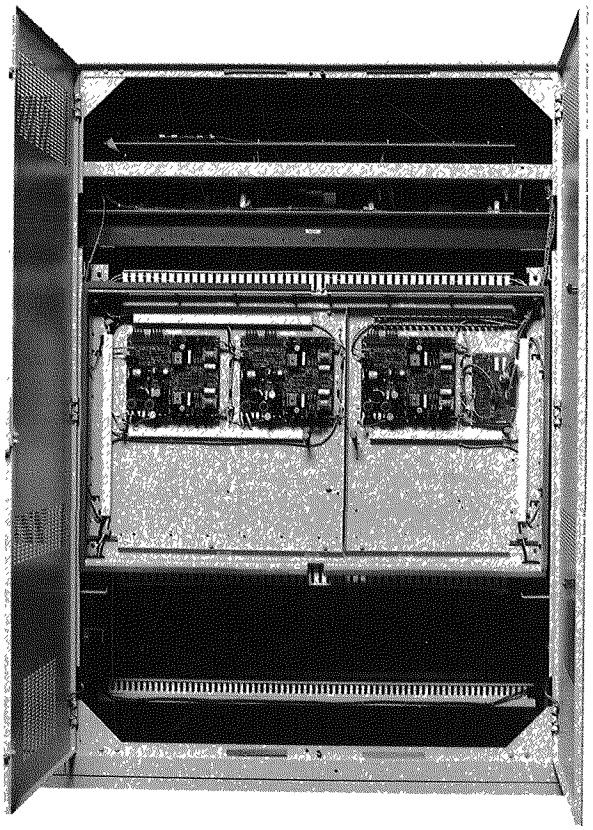
The reduced starting current and lack of short circuit contribution also allows an increase of the total motor load that can be applied to a piece of switchgear. For an existing system there is a reduced voltage dip during motor starting and lower short circuit duty.

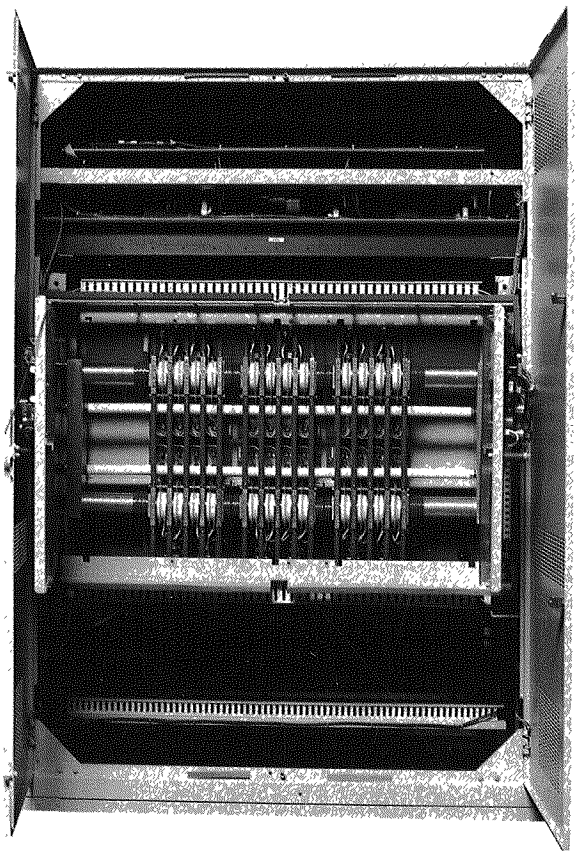
Bus Voltage Variation Resistant

Since the LCI motor is buffered from the power bus, it is less sensitive to voltage fluctuation. If there is a momentary dip in voltage the LCI will continue to produce torque or coast (depending upon the magnitude of the dip) until voltage is returned. It will then re-accelerate to the desired speed. The LCI motor will not pull out of step like a fixed speed motor, but will continue to operate. As a result, the LCI is ideal for power plant applications where bus switching is a common occurrence.

Regenerative

A synchronous motor can also be a generator. When a large inertial load is driven by an LCI with a synchronous motor, the inertia can be used to drive the motor as a generator, slowing the motor and load inertia, feeding the generated power back into the ac line. Line regeneration is an effective, cost efficient way to provide braking of a large inertia load.





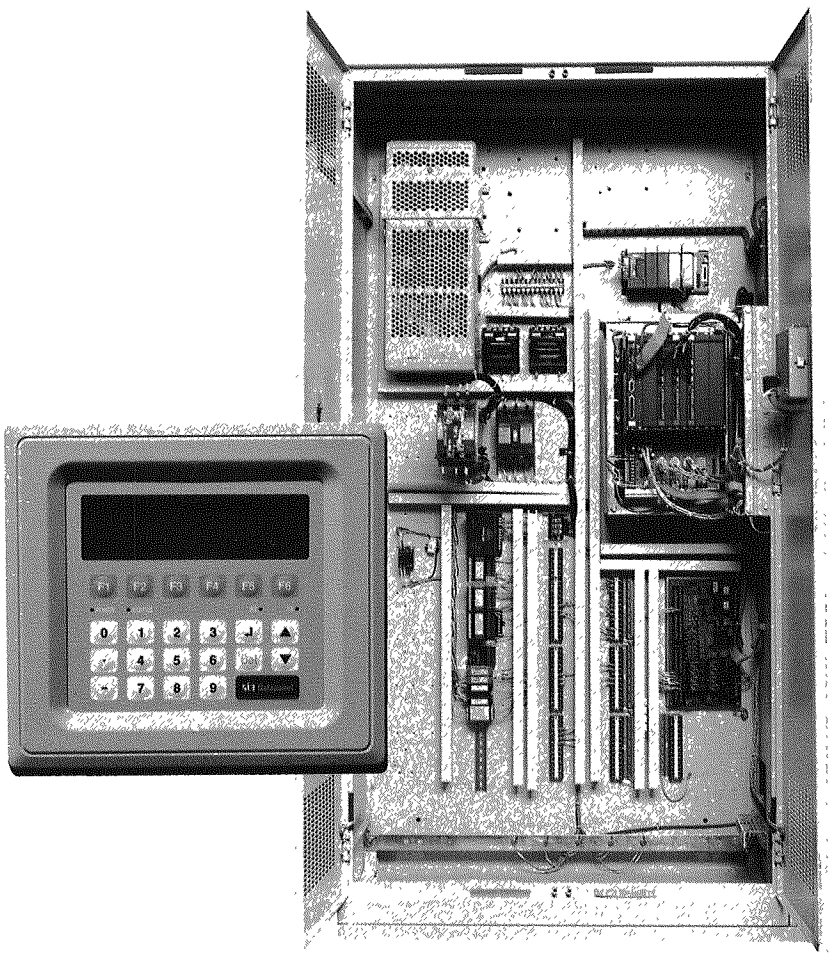
Keeping you in control

Digital Performance and Accuracy

To optimize performance, a floating point Digital Signal Processor (DSP) is used on all systems. This processor has twenty times more processing power than those used in previous generations of controls. The result is higher drive reliability and control performance, more comprehensive, higher-quality protection, and better fault avoidance.

Simpler Design

Control cards are mounted in a VME rack, designed for simplified maintenace in rugged industrial applications. The number of control cards has been minimized. The rack-based design drastically reduces wiring and connectors which means there are less opportunities for faults to develop. Best of all fewer spare parts need to be stocked and repair time has been reduced.



Bridge Control Functions

Drive parameters and control functions are scaled on a per unit basis to match the motor to be controlled. Control signal circuitry is isolated from high voltage circuitry and utilizes fiber optic cabling to provide electrical noise immunity. Drive configuration and tune-up data are retained in non-volatile memory and can be backed-up with a personal computer.

All bridge control functions are performed in the DSP module. These include:

Speed regulation
Current regulation
Flux regulation
Source converter thyristor firing
Load converter thyristor firing.

The bridge control features hardware which is independent of the DSP operation. This protects against over-current in source or load bridges. No power fuses are necessary. There is a DSP independent customer signal path which disables power bridge gating useable for external interlocks.

The use of a high-current, low-voltage thyristor gating strategy with dc output ensures positive, noise immune gating for the SCRs.

System Control Functions

System interfaces for command input, sequencing and interlocks, and status feedback are provided through an expandable Programmable Logic Controller (PLC). The PLC can be a GE-Fanuc 90-30 external to the bridge control module or a GE Industrial Control Systems UC2000 processor integrated into the bridge control module. Either PLC uses GE-Fanuc Field I/O modules hosted on a local Genius® Bus as expandable customer and system I/O.

The use of a standard PLC provides for a wealth of drive communications options which include Ethernet™, DLAN+, Genius® Bus, SNP, Modbus®, Interbus-S™, and others. The field I/O modules offer a DIN rail-mounted, expandable I/O system to handle application specific interface needs.

Extended Self Diagnostics

The control is designed with extensive test features which are able to isolate problems to a replaceable unit. All bridge control boards feature loop-back test capability which allows the processor to test the board operation without requiring motor operation. All cables are monitored for continuity.

All thyristors are individually monitored for proper conduction status. In drives with optional redundant thyristors, safe operation of the drive can continue with one or more shorted devices until maintenance is performed.

The control is also capable of running a test on the entire drive where current is circulated through the bridges but bypasses the motor, allowing proof of drive readiness without requiring power on the motor.

Help is as Near as Your Modem

GE's OnSite™ remote monitoring, diagnostics and service program is available from GE Engineering Services. It provides 24-hour diagnostic services and software support anywhere in the world. This program is provided by skilled GE installation and service engineering personnel familiar with your application and equipment.

One single contact can provide service, parts and training to keep you up and running.

Cooling System

All major heat producing components in the LCI are liquid cooled. The enclosure is convection cooled and requires only a small amount of air conditioning in the control room. The cooling fluid in the LCI is cooled either by a liquid-to-air heat exchanger or a liquid-to-liquid heat exchanger. Liquid cooling provides a compact drive with maximum rating available from the SCRs.

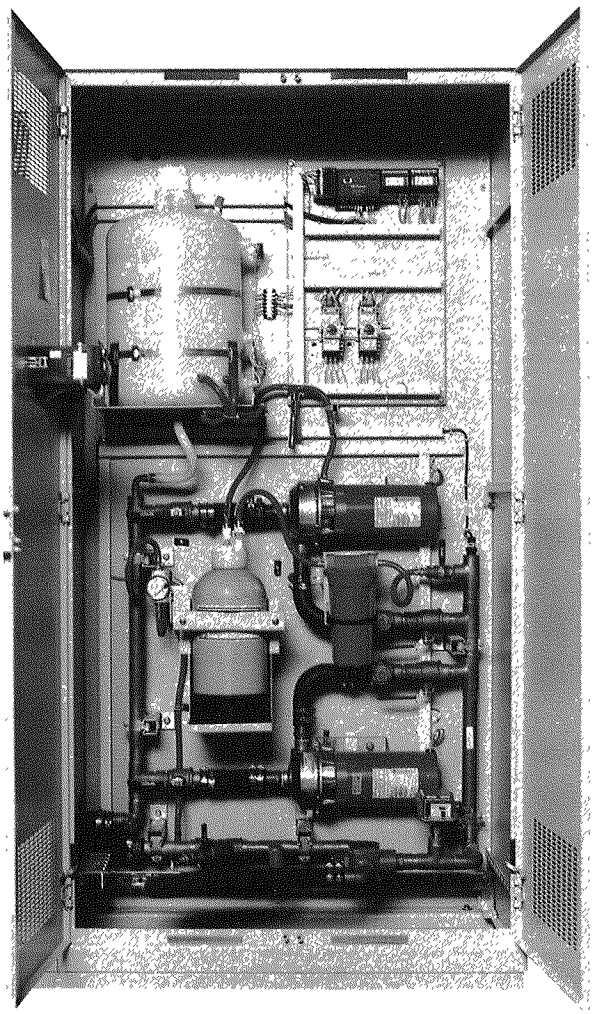
Tachometer (Optional)

A tachometer is available for specialized low speed and constant speed applications when required. For most applications, the motor speed is regulated by comparing the speed reference from the process controller to the feedback derived from the motor terminal voltage.

Initialization

Upon application of power to the drive the following checks are performed to prevent an abnormal microprocessor condition, and to prevent improper drive operation.

CPU test
PROM check sum
RAM test



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Drive Control Strategy

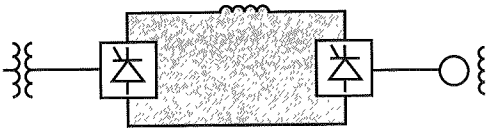
The Load Commutated Inverter's theory of operation is simple and reliable. It uses load-commuted, phase-controlled power technology to supply power to the stator windings of the synchronous machine.

The power circuit has a source converter, connected to the power supply and a load converter connected to the motor. When motoring, power flows from the power source to the motor.

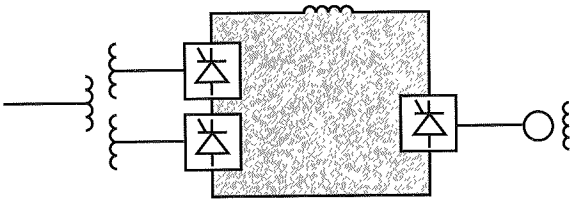
The LCI controls motor torque to regulate motor speed. Motor torque is controlled through the dc link current. In most operating conditions, the source converter controls the link current by changing the voltage across the link reactor.

The link reactor also limits ripple current that flows between the source and the load converters. Properly sized, the link reactor will prevent SCR failures when a commutation failure occurs on the load converter. Under these circumstances, the LCI can continue to operate without tripping off-line.

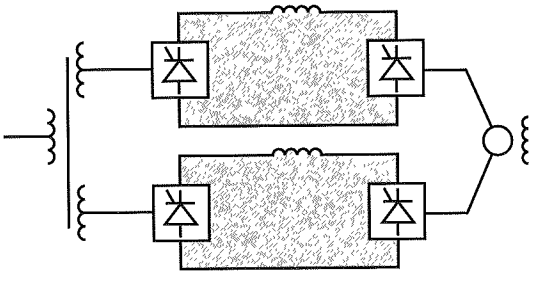
System Configurations:



6 PULSE / 6 PULSE



12 PULSE / 6 PULSE



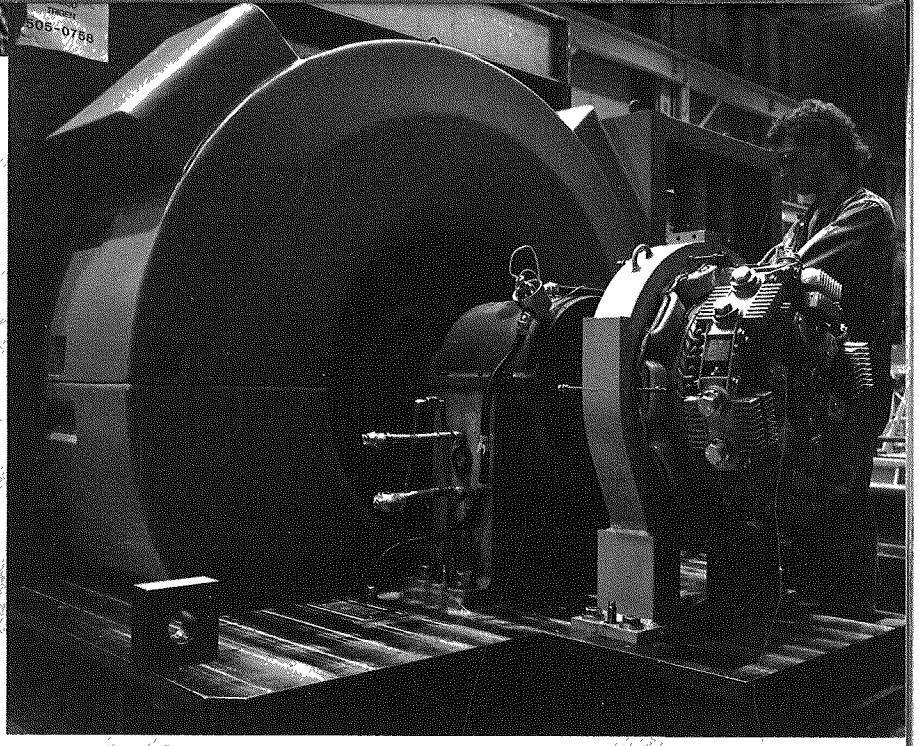
12 PULSE / 12 PULSE

Ratings

VOLTS	PULSES		DIMENSIONS meters			WEIGHT	kW @ 50°C 50% Antifreeze	kW @ 35°C
	Source	Load	W	D	H			
2300	6	6	4.0	1.4	2.3	4400	5000	5250
2300	12	12	5.6	1.4	2.3	7400	10000	10500
4160	6	6	5.6	1.4	2.3	7400	12000	14200
4160	12	6	5.6	1.4	2.3	7400	12000	14200

** Additional voltages and ratings can be provided by special request to meet application requirements*

For 2300 volt applications requiring a 12-pulse dual channel LCI configuration, a more effective single line-up is offered as shown above. This compact design has a single control and cooling system.



Motor Design

The LCI is designed as a system. Both the control and the motor are coordinated and designed to work together. GE's motor design engineers and drive engineers work together to assure system compatibility. GE's long experience in motor design and manufacturing means every LCI system will provide a very high degree of reliability.

The synchronous motor for the LCI has several design differences not found in a standard synchronous motor.

Construction

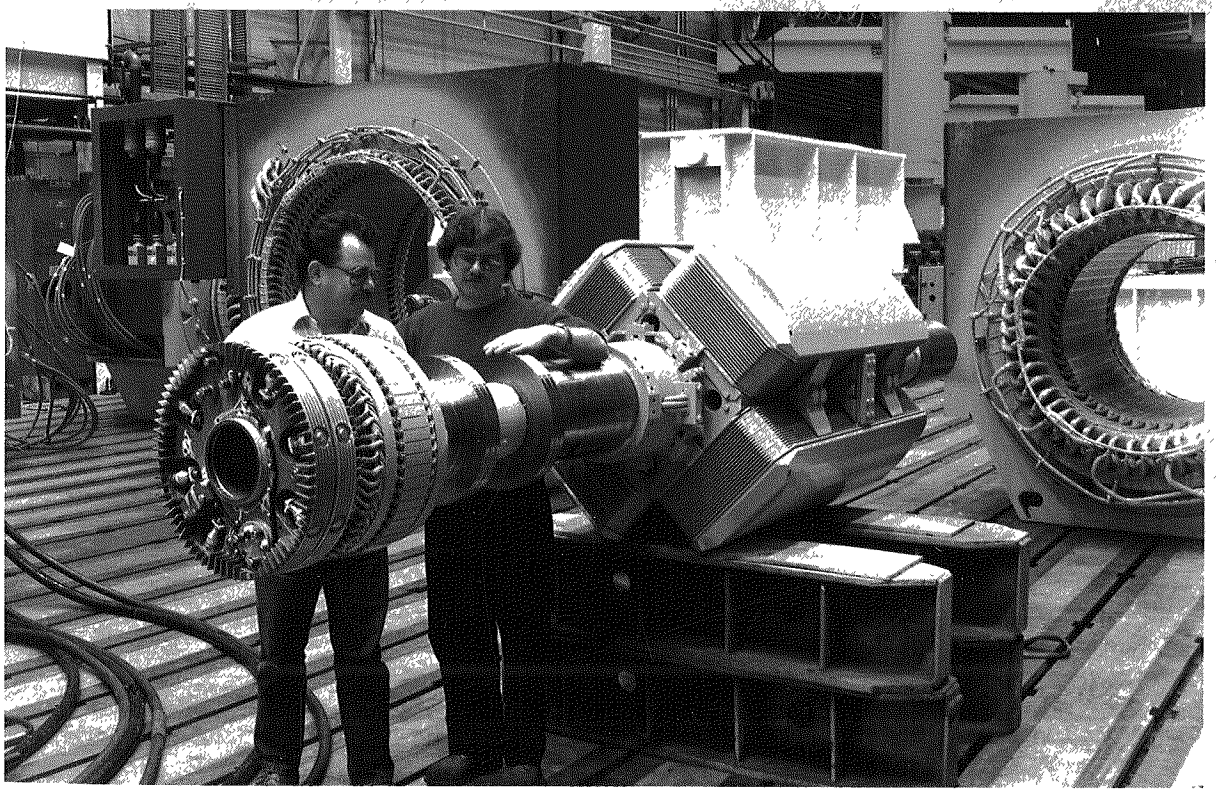
The ammortisseur windings in the LCI motor are designed to minimize the losses caused by the harmonic content of the drive current waveform. The design of these bars is such that the LCI synchronous motor cannot be started across the line. For twelve-pulse operation the motor has two windings that are 30 electrical degrees apart.

Excitation

Brushless field exciters are standard, however slip rings are also available. The LCI control sets the flux of the machine to best suit the application and deliver the highest power factor and efficiency over the entire speed range.

Motor Power Factor

The LCI synchronous motor operates at leading power factor to provide the reactive power required to commutate the inverter thyristors. This operation is a fundamental difference between the LCI and other ac drive technologies.



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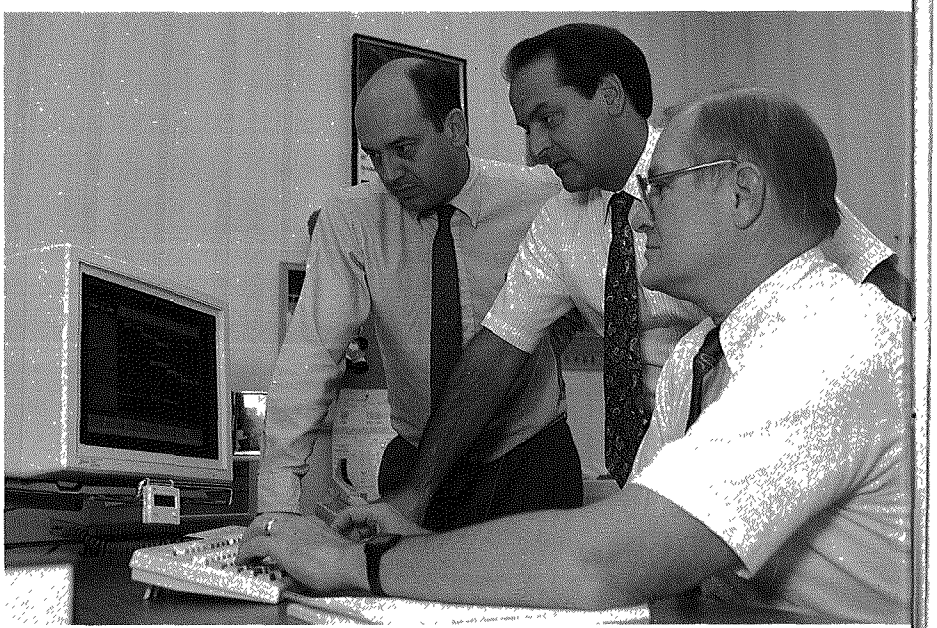
Getting Started



Installation and Startup Supervision

The world-wide GE service network is available for turnkey installation, startup supervision, and service.

GE's OnSite™ remote monitoring and diagnostics system provides on-line support from a team of engineers who have strong application experience and ac drive and motor knowledge. They are available 24 hours a day to support your team in the event of an outage or equipment instability. When you telephone, they can tie into your system to provide quick assistance to pinpoint system problems and identify potential solutions. Think of OnSite™ as a team of experts, poised to help you quickly resume profitable production.

Parts Support

Spare parts are readily available from GE Engineering Services Renewal Parts Operation in Salem, Virginia or through the worldwide network of renewal parts distributors. Emergency phone service is provided 24 hours a day. Most renewal parts are filled from stock and shipped within 24 hours.

Training

Training courses tailored to your needs are available for both operating and maintenance personnel right on your site, or at the GE Training Center in Salem, Virginia.

Project Management

GE provides single point system responsibility. From the application analysis to the final installation, a GE engineer is your point of contact. Knowledge of your system, experience, application expertise, competence, and integrity make your GE engineer a valuable asset.

Commitment

GE is committed to providing our customers with the most up-to-date, proven technology available. We strive to help solve your problems and to provide an exceptionally dependable system manufactured to Six Sigma quality standards. These standards are designed to effectively eliminate all defects from every product, process and transaction in which GE engages around the globe. It is based on the statistical measurement defined as fewer than 3.4 defects per million opportunities. With GE, you know that we will be available throughout the life of your equipment. Best of all, you can be confident that you are working with a company that has the resources, knowledge and experience to do the best job.

Technical Data

Control Features:

- Forced Commutation Below 10% of Rated Speed
- Load Commutation Above 10% of Rated Speed
- Torque Regulated Speed Control
- Volts / Hz Control
- Field Excitation Control
- 10-160% of Rated Speed Control Range
- 3 Programmable Acceleration / Deceleration Ramps (Max Rate of 10% / Sec)
- Smooth Reversal of Motor Rotation Through Zero Speed

	No Tachometer	Tachometer
Max Starting Torque (From Standstill)	.75 PU	2.0 PU
Max Forward Speed	1.0 PU	1.0 PU
Max Reverse Speed	0.5 PU	1.0 PU
Constant Horsepower Speed Range	Base to Top	Base to Top
Constant Torque Speed Range	0.1 PU to Base	1.5-Hz to Base

Impact Loading

- Below Base Speed 1.0 PU Torque/Sec 3.0 PU Torque/Sec
- Above Base Speed 0.5 PU HP/Sec 1.5 PU HP/Sec

Short Circuit Bracing:

30,000 Amps Symmetrical

Cooling Media:

- Deionized Water
- 50°C Max Inlet Water Cooling Temperature (Water-to-Water Heat Exchanger)
- Optional Addition of Antifreeze (Requires Derating Drive)
- Operating Ambient Air Range (0-50°C)

Manufacturing Standards:

- UL508C
- IEC 146-1-2
- NEMA ICS 7-1993
- CSA C22.2
- UL347A
- EN50178

Manufacturing Quality System:

- ISO9001
- ISO9000-3

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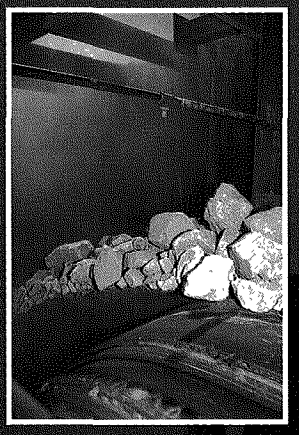

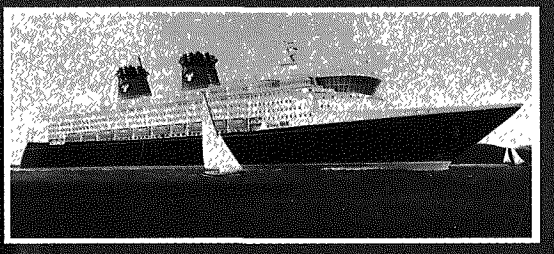

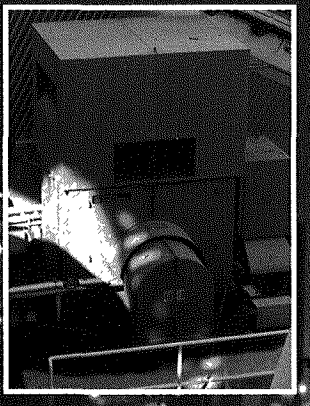

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